WORKSHOP ON THE POLAR REGIONS OF MARS: GEOLOGY, GLACIOLOGY, AND CLIMATE HISTORY

MSATT

Mars Surface and Atmosphere Through Time

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Lunar and Planetary Institute 3600 Bay Area Boulevard Houston TX 77058-1113

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WORKSHOP ON

THE POLAR REGIONS OF MARS:

GEOLOGY, GLACIOLOGY, AND CLIMATE HISTORY

Edited by

S. M. Clifford, A. D. Howard, and W. S. B. Paterson

Held at
Houston, Texas

November 13–15, 1992

Sponsored by
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The MSATT Study Group

Lunar and Planetary Institute 3600 Bay Area Boulevard Houston TX 77058-1113

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Program

Friday morning, November 13, 1992

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S. Clifford*

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R. Zurek*

Geology of Martian Polar Regions
A. Howard*

Thermophysical Properties and Remote Sensing of Martian Polar Regions
D. Page*

Mars Climate History
H. Kieffer*

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G. North*

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* Denotes speaker

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J. S. Kargel*

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J. W. Rice*

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D. M. Anderson*

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D. Fisher*

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Modeling Interannual Variability in the Martian CO_2 Cycle
S. E. Wood* and D. A. Paige

The Interannual Variability of Polar Cap Recessions as a Measure of the Martian Climate and Weather: Using Earth-based Data to Augment the Time Line for Mars Observer
L. J. Martin* and P. B. James

Is CO_2 Ice Permanent?
B. E. Lindner*

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J. R. Murphy* and J. B. Pollack

Numerical Simulations of Drainage Flows on Mars
T. R. Parish* and A. D. Howard

Wind Transport Near the Poles of Mars: Timescales of Change in Deposition and Erosion
P. C. Thomas*

Saturday afternoon, November 14, 1992

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H. Kieffer*

Mars Observer Radio Science (MORS) Observation in the Polar Regions
R. Simpson*

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W. C. Feldman*, W. V. Boynton, J. I. Trombka, J. R. Arnold, P. A. J. Englert, A. E. Metzger, R. C. Reedy, S. W. Squyres, and H. Wänke

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P. C. Thomas*

SESSION VII: FOCUSED DISCUSSION SESSION
Topic: What Can We Learn About the Poles from Mars Observer, and What Other Types of Investigations Should be Included in Future Missions?

Evolution of the Martian Atmosphere: The Role of the Polar Caps
R. M. Haberle*, D. Tyler, C. P. McKay, and W. Davis

The Polar Layered Deposits on Mars: Inferences from Thermal Inertia Modeling and Geologic Studies
K. E. Herkenhoff*

The Mars Water Cycle at Other Epochs: Recent History of the Polar Caps and Layered Terrain
B. M. Jakosky*, B. G. Henderson, and M. T. Mellon

Orbital, Rotational, and Climatic Interactions: Lessons from Earth and Mars
B. G. Bills*

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Summary of Technical Sessions

Nowhere is there clearer evidence of seasonal and climatic change on Mars than in its polar regions, yet our understanding of the geology and evolution of these regions is exceedingly poor. How did the current caps originate? What is their composition? How have changes in martian obliquity, precession, and orbital eccentricity affected the annual cycles of CO_2, H_2O, and dust? What are the thermal properties and rheology of the polar ice? Is there evidence of glacial flow? These are just a few of the questions that were addressed by the 45 participants attending the MSATT workshop on "The Polar Regions of Mars: Geology, Glaciology, and Climate History" held November 13–15, 1992, at the Lunar and Planetary Institute in Houston.

The primary purpose of the workshop, which was convened by Steve Clifford of LPI, Alan Howard of the University of Virginia, and Stan Paterson of Paterson Geophysics, was to assess the state of Mars polar research in anticipation of the arrival of Mars Observer. The meeting brought together researchers from such diverse fields as martian atmospheric dynamics, climate, volatiles, geophysics, and polar geology. It also benefited from the participation of scientists from the terrestrial community—whose perspectives on glaciology and climate change are based on a far more extensive body of theoretical, experimental, and field research. Among the terrestrial scientists participating in the meeting were glaciologists David Fisher, Richard Hindmarsh, John Nye, and Stan Paterson; climate researcher Gerald North; and ice rheologist and experimentalist William Durham.

To provide everyone with a common background for discussion, the first two sessions of the workshop were devoted to reviews and tutorials on broad areas of martian and terrestrial polar research. These included discussions of the geology and glaciology of the polar caps, their physical and rheologic properties, and the role of seasonal and climate change in their evolution. This introduction was followed by an afternoon session that focused on several more detailed aspects of martian polar geology—including the topographic influence of large impact basins on the structure and distribution of the polar deposits, the possibility of basal lakes, and evidence of past glaciation in Elysium and at the poles.

The possibility of glacial flow was discussed at greater length that evening. David Fisher, from the Geological Survey of Canada, kicked off the discussion with a talk entitled "A Terrestrial Glaciologist's View of Mars." He began by reviewing two previously published studies of the possibility of glacial flow in the martian north polar cap. He noted that while both studies found that the possibility of glacial flow was real, both were seriously handicapped by our current ignorance of such fundamental characteristics as the local thickness and basal topography of the polar ice—a problem that Fisher suggested could be addressed through the use of either seismic or radio echo sounding techniques in future investigations of the caps. Discussion of possible evidence for glacial flow led to the consensus that while features resembling terrestrial eskers and terminal moraines have been identified in the martian polar regions, the accuracy of this interpretation is at best equivocal. Our ability to make a more definitive assessment is expected to improve significantly with the arrival of Mars Observer—whose polar orbit, high-resolution camera, and laser altimeter will provide investigators with a wealth of new images and topographic data over both of the caps.

Another topic raised during Friday evening's discussion was the origin of the polar troughs. Fisher demonstrated that if the caps were currently flowing, and if their flow centers were displaced from the planet's rotational poles, then the sunward-facing scarps in the ice would naturally evolve by sublimation and poleward migration into a spiral pattern sharing many of the characteristics displayed by the actual caps. This prompted Nye, from the University of Bristol, to contribute his own suggestion, arguing that each cap is likely to behave much like a thermally conducting cylinder that rotates slowly about its axis while being heated from one direction by a distant source; as the resulting temperature waves propagate into the cylinder, the isotherms (viewed along the cylinder's rotation axis) will describe a spiral pattern. Although conceding that this fact alone does not provide an obvious explanation for the origin of the troughs, Nye speculated that it may play a contributing role.

On Saturday morning the workshop focused on how the atmospheric dynamics, surface energy budget, and seasonal cycles of CO_2 and dust on Mars affect the formation and interannual variability of the seasonal polar caps. Speakers reviewed both spacecraft and Earth-based telescopic observations of seasonal cap retreat and discussed their significance with regard to various processes affecting cap behavior. Additional information, regarding the direction of strongest seasonal and prevailing long-term ($\sim 5 \times 10^4$ yr) surface winds, is provided by the orientation of wind streaks and dunes. Taken together, these data provide important constraints and checks for the development of general circulation and climate models of both the past and present epochs.

Later that afternoon, representatives from each of the Mars Observer investigation teams discussed their instruments and their application to Mars polar research. These presentations were followed by an open discussion about what we could expect to learn from Mars Observer and what types of other investigations (e.g., radar sounders, penetrators, etc.) should be included in future missions.

The last group of talks, presented during the morning session on Sunday, dealt with the evolution of the martian climate. One study suggests that the decline in atmospheric pressure on Mars may have been strongly influenced by the planet's initial inventory of atmospheric CO_2. If the initial inventory was as high as 5 bar, then pressures in excess of several hundred millibars may

have persisted for as much as 2 b.y. However, an initial inventory of 1 bar or less would have led to an almost immediate collapse of atmospheric pressure to near its present level. Another key driver of past climates has been the extent to which the martian obliquity has varied with time. The extent of this variation is sensitively dependent on the planet's moment of inertia—a value that is poorly constrained at present, but which should be known to fairly good accuracy with the determination of the spin axis precession rate by Mars Observer.

At the close of the meeting on Sunday, a summary panel discussion was held of both planetary and terrestrial researchers who assessed the state of Mars polar research and offered opinions regarding what future efforts were likely to be the most critical to our understanding of the nature and development of the poles. Looking ahead to the near future, the panelists cited the improved temporal coverage, compositional information, high-resolution imaging, topographic data, and precession rate determination that are anticipated from the Mars Observer mission. Additional recommended investigations included active seismic or radio echo sounding to directly measure the thickness, structure, and basal topography of the polar deposits, and the emplacement of a number of surface stations to assess the local meteorology, mass balance, and composition of the caps.

In evaluating the success of the workshop, the comments made by the participants were remarkably consistent. The two elements that the members of the planetary community most appreciated were the emphasis placed on open discussion and the participation of scientists from the terrestrial community. Similar opinions were expressed by the terrestrial participants, many of whom indicated a strong desire to become more involved in Mars polar and climate research. Recommendations from both groups included numerous requests for another workshop following the initial analysis of the Mars Observer data. While the workshop's written abstracts and formal presentations were its most visible products, for those who attended, the things that were valued most were the many stimulating discussions, new contacts, and possibilities for future collaboration—all of which will benefit Mars research for many years to come.

(***Note added in proof:*** Although the loss of the Mars Observer spacecraft on August 21, 1993, was a major disappointment, much of the science that was anticipated from that mission is scheduled to be recovered with the 1996 launch of the Mars Global Surveyor. Two years later, a smaller spacecraft, carrying the balance of the original Mars Observer instrument package, will be launched to complete the global survey.)

List of Workshop Participants

Judith H. Allton
Mail Code C23
Lockheed Engineering and Sciences Company
2400 NASA Road 1
Houston TX 77058
Phone: 713-483-5766
Fax: 713-483-5347
E-mail: allton@snmail.jsc.nasa.gov

Duwayne M. Anderson
Department of Geology
267 Halbouty Building
Texas A&M University
College Station TX 77843-3115
Phone: 409-845-8585
Fax: 409-845-3138
E-mail: anderson@archone.tamv.edu

Nadine G. Barlow
Lunar and Planetary Institute
3600 Bay Area Boulevard
Houston TX 77058
Phone: 713-280-9021
Fax: 713-480-1279
E-mail: barlow@lpi.jsc.nasa.gov

Deborah Bass
Department of Earth and Space Sciences
University of California, Los Angeles
Los Angeles CA 90024
Phone: 310-825-6168
Fax: 310-825-2779
E-mail: debbie@thesun.ess.ucla.edu

Paul Bass
6719 Park Lane
Houston TX 77023
Phone: 713-684-4018

Bruce Bills
Mail Code 921
Geodynamics Branch
NASA Goddard Space Flight Center
Greenbelt MD 20771
Phone: 301-286-8555

Robert Burnham
Astronomy Magazine
P.O. Box 1612
Waukesha WI 53187
Phone: 414-798-6572
Fax: 414-796-1142
E-mail: 72000.2704@compuserve.com

John Capuano
University of Toledo
Ritter Observatory
Toledo OH 43606

Stephen Clifford
Lunar and Planetary Institute
3600 Bay Area Boulevard
Houston TX 77058
Phone: 713-486-2146
Fax: 713-486-2160
E-mail: clifford@lpi.jsc.nasa.gov

Gerlind Dreibus
Max-Planck-Institut für Chemie
Postfach 3060
Saarstrasse 23
Mainz D-55122
GERMANY
Phone: 49-6131-305395
Fax: 49-6131-37129

William B. Durham
L-201
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore CA 94550
Phone: 415-422-7046
Fax: 510-423-1057
E-mail: durham@538.es.llnl.gov

William C. Feldman
Los Alamos National Laboratory
1516 45th Street
Los Alamos NM 87544
Phone: 505-667-7372
Fax: 505-665-3332
E-mail: wfeldman@sstcxi.lanl.gov

David Fisher
Geology Department
University of Miami
Miami FL 33124
Phone: 305-284-3254
Fax: 305-284-4258

Herbert Frey
Code 921
Geophysics Branch
NASA Goddard Space Flight Center
Greenbelt MD 20771-0001
Phone: 301-286-5450
Fax: 410-286-1616
E-mail: frey@denali.gspc.nasa.gov

Bob Haberle
Mail Stop 245-3
Space Science Division
NASA Ames Research Center
Moffett Field CA 94035
Phone: 415-604-5491
Fax: 415-604-6779
E-mail: haberle@humbabe.arc.nasa.gov

Ken Herkenhoff
Mail Stop 183-501
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena CA 91109-8099
Phone: 818-393-0738
Fax: 818-354-0966
E-mail: keh@jplsc8.jpl.nasa.gov

Richard Hindmarsh
High Cross
Madingley Road
Cambridge
UNITED KINGDOM
Phone: 44-223-61188

Harald Hoffmann
DLR Institute for Planetary Exploration
D-8031 Wesslingfenhofen
GERMANY
Phone: 49-8153-281322
Fax: 49-8153-2476
E-mail: OOEPES::HOFFMANN

Alan Howard
Department of Environmental Sciences
University of Virginia
Charlottesville VA 22903
Phone: 804-924-0563
Fax: 804-982-2137
E-mail: ahgp@virginia.edu

Bruce Jakosky
Laboratory for Atmospheric and Space Physics
University of Colorado
Campus Box 392
Boulder CO 80309-0392
Phone: 303-492-8004
Fax: 303-492-6946
E-mail: ZODIAC::JAKOSKY

Phil James
Physics and Astronomy Department
University of Toledo
Toledo OH 43606
Phone: 419-537-4906
Fax: 419-537-2723
E-mail: pbj@utphya.phya.utoledo.edu

Jeff Kargel
Astrogeology Branch Laboratory
U.S. Geological Survey
2255 N. Gemini Drive
Flagstaff AZ 86001
Phone: 602-556-7034
Fax: 602-556-7014

Hugh Kieffer
2255 N. Gemini Drive
U.S. Geological Survey
Flagstaff AZ 86001
Phone: 602-527-7015
Fax: 602-556-7014
E-mail: h.kieffer@nasamail.nasa.gov

B. Lee Lindner
AER, Inc.
840 Memorial Drive
Cambridge MA 02139
Phone: 617-349-2280
Fax: 617-661-6479

Baerbel K. Lucchitta
U.S. Geological Survey
2255 North Gemini Drive
Flagstaff AZ 86001
Phone: 602-527-7176
Fax: 602-556-7014

Leonard Martin
Lowell Observatory
1400 Mars Hill Road West
Flagstaff AZ 86001
Phone: 602-774-3358
Fax: 602-774-6296
E-mail: ljm@lowell.edu

Scott Murchie
Applied Physics Laboratory
Johns Hopkins University
Laurel MD 20723
Phone: 301-953-6000 ext. 8682

Jim Murphy
Building N-245
NASA Ames Research Center
Moffett Field CA 94035
Phone: 415-604-3119
Fax: 415-604-6779
E-mail: murphy@anarchy.arc.nasa.gov

Gerhard Neukum
NE-PE
DLR
Rudower Chaussee 5
12484 Berlin
GERMANY
Phone: 49-3069545310
Fax: 49-3069545313
E-mail: 28842::NEUKUM

Gerald R. North
Department of Meteorology
Texas A&M University
College Station TX 77843-3150

John F. Nye
H. H. Wills Physics Laboratory
Bristol University
Tyndall Avenue
Bristol BS8
UNITED KINGDOM
Phone: 44-272-303030 Ext. 3697
Fax: 44-272-255624

Adrienne Ono
Department of Earth and Space Sciences
University of California, Los Angeles
Los Angeles CA 90024-1567
Phone: 310-206-9292

David A. Paige
Department of Earth and Space Sciences
University of California, Los Angeles
Los Angeles CA 90024
Phone: 310-825-4268
Fax: 310-825-2779
E-mail: dap@thesun.ess.ucla.edu

Thomas R. Parish
Department of Atmospheric Science
University of Wyoming
P.O. Box 3038
Laramie WY 82071-3038
Phone: 307-766-5153
Fax: 307-766-2635
E-mail: parish@lynx.uwyo.edu

Stan Paterson
Box 303
Paterson Geophysics Inc.
Heriot Bay
British Columbia V0P 1HO
CANADA
Phone: 604-285-3337
Fax: 604-285-2430

Jeff Plaut
Mail Stop 230-225
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena CA 91109
Phone: 818-393-0875
Fax: 818-393-0503
E-mail: JPLMWZ::JJP342

Jeff Plescia
Mail Stop 183-501
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena CA 91109
Phone: 818-354-6936
Fax: 818-354-0966
E-mail: jplescia@nasamail.nasa.gov

Jim Rice
Department of Geography
Arizona State University
Tempe AZ 85287
Phone: 602-965-7533
Fax: 602-965-8313
E-mail: asjwr@asuvm.inre.asu.edu

Mark Richardson
Department of Earth and Space Sciences
University of California, Los Angeles
Los Angeles CA 90024-1567
Phone: 310-825-6168
E-mail: mark@thesun.ess.ucla.edu

Ben Schuraytz
Lunar and Planetary Institute
3600 Bay Area Boulevard
Houston TX 77058
Phone: 713-486-2187
Fax: 713-486-2162
E-mail: schuraytz@lpi.jsc.nasa.gov

Dick Simpson
Durand Building, Room 232
Stanford University
Stanford CA 94305-4055
Phone: 415-723-3525
Fax: 415-723-9251
E-mail: rsimpson@nova.stanford.edu

Peter Thomas
422 Space Sciences
Cornell University
Ithaca NY 14853
Phone: 607-255-5908
Fax: 607-255-9002
E-mail: COSPIF::THOMAS

Heinrich Wänke
Abteilung Kosmochemie
Max-Planck-Institut für Chemie
Saarstrasse 23
Mainz D-55122
GERMANY
Phone: 49-6131-305230
Fax: 49-6131-371290
E-mail: waenke@mpch-mainz.mpg.d400.de

Stephen Wood
Department of Earth and Space Sciences
University of California, Los Angeles
Los Angeles CA 90024
Phone: 310-206-9292
Fax: 310-825-2779

Richard Zurek
Mail Stop 169-237
Jet Propulsion Laboratory
4800 Oak Grove Dr.
Pasadena CA 91109
Phone: 818-354-3725
Fax: 818-393-4619
E-mail: rwz@rich.jpl.nasa.gov